

Computer Models

EES 3310/5310

Global Climate Change

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Class #16: Monday, March 1 2021

Climate and Economy

Climate and Economy

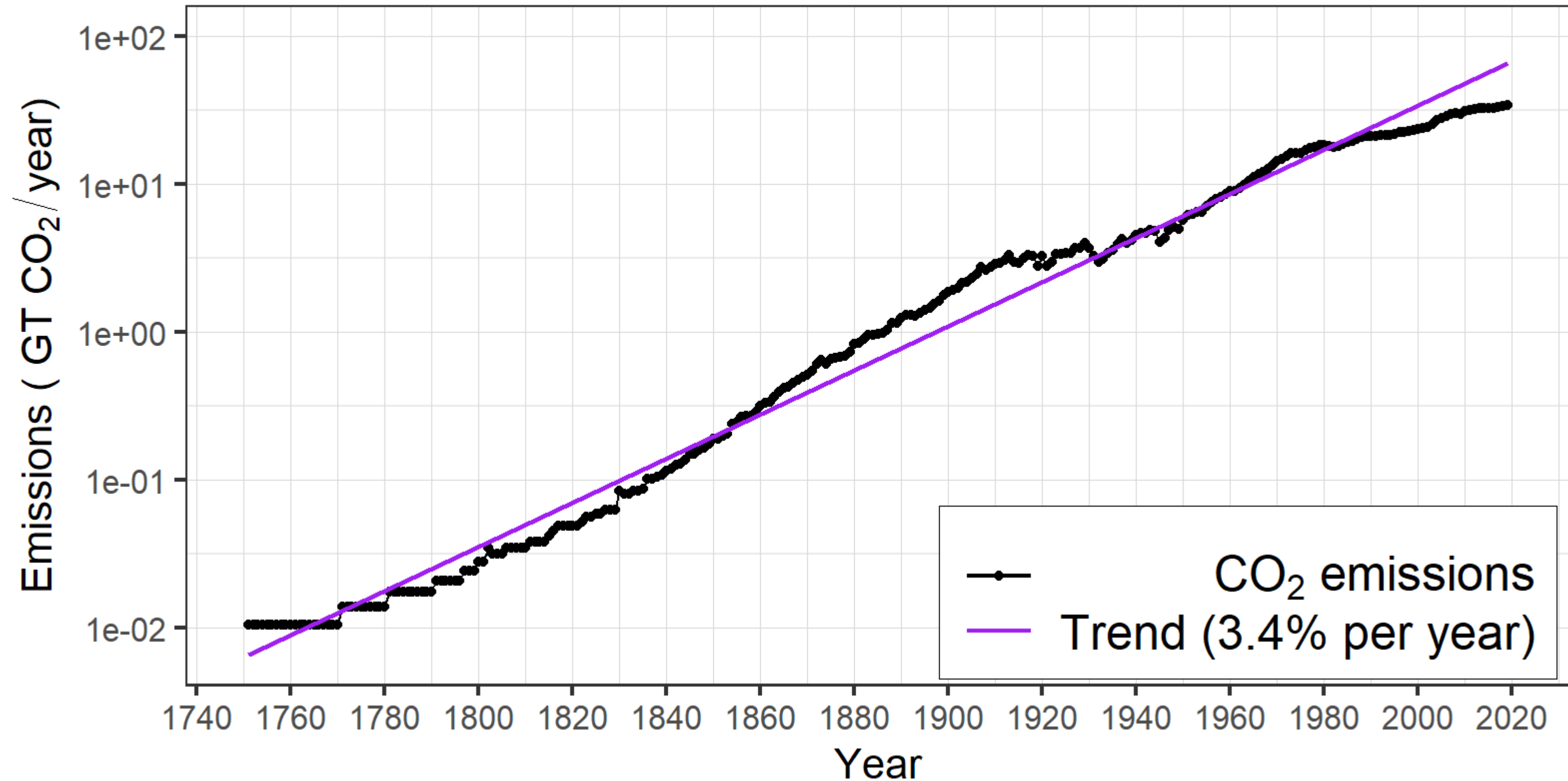
How well do markets manage global warming?

- How well do markets manage supply and price of bread?
- What is different about global warming?
- Externalities:
 - What is an externality?
 - Are externalities good or bad?
 - What challenges to they pose for markets?
 - How can market-based economies manage externalities better?

Discuss for 5 minutes in breakout rooms

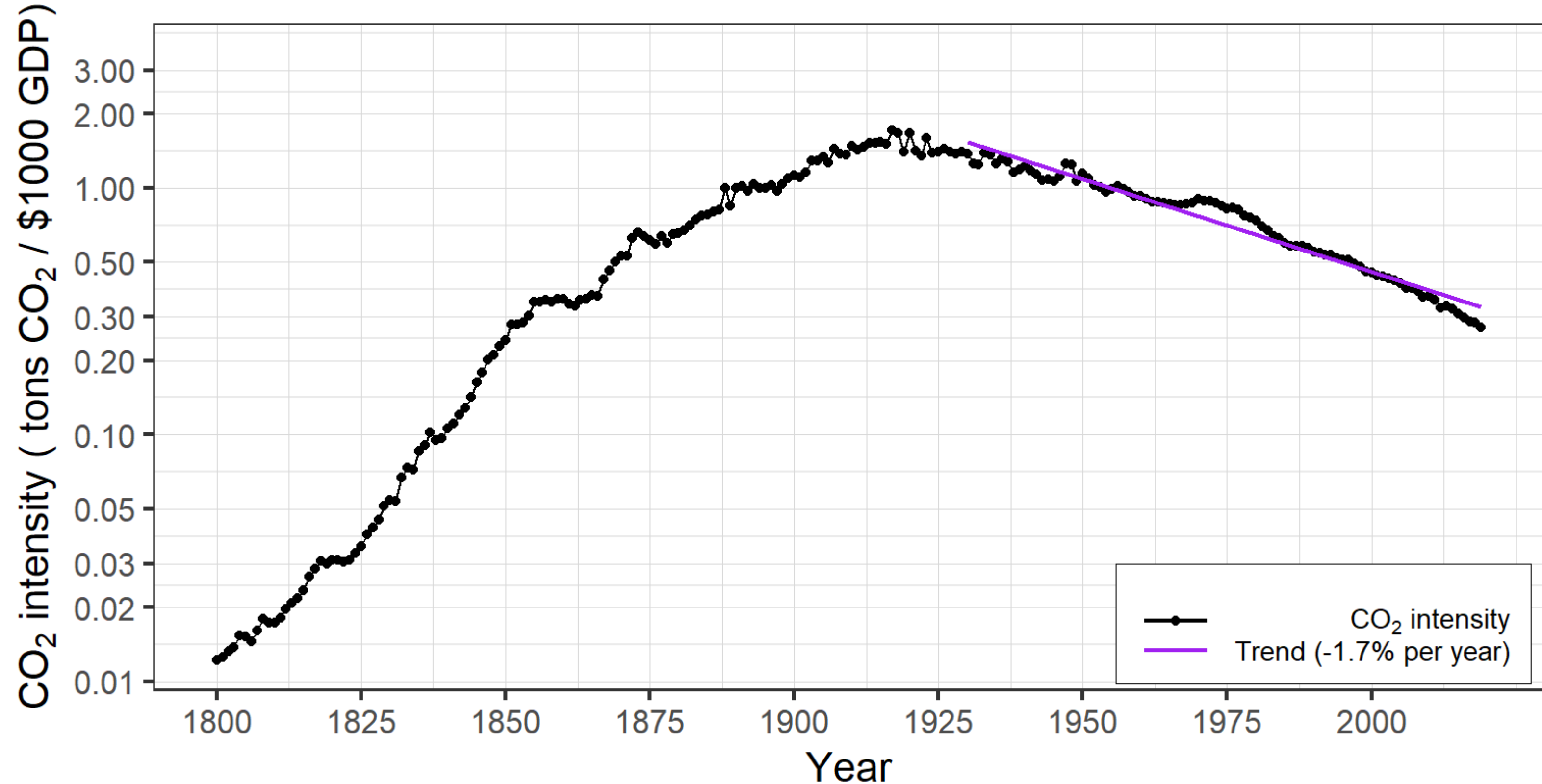
Energy, Economy, Emissions

Global CO₂ emissions 1751-2019



Energy, Economy, Emissions

CO₂ intensity of the US economy 1800-2019



Kaya Identity

Kaya Identity

$$P \times \frac{G}{P} \times \frac{E}{G} \times \frac{F}{E} = F,$$

where

F = CO₂ emissions

E = energy use

G = gross domestic product

P = population

Kaya Identity

$$\begin{aligned} F &= P \times \frac{G}{P} \times \frac{E}{G} \times \frac{F}{E} \\ &= P \times g \times e \times f \end{aligned}$$

where

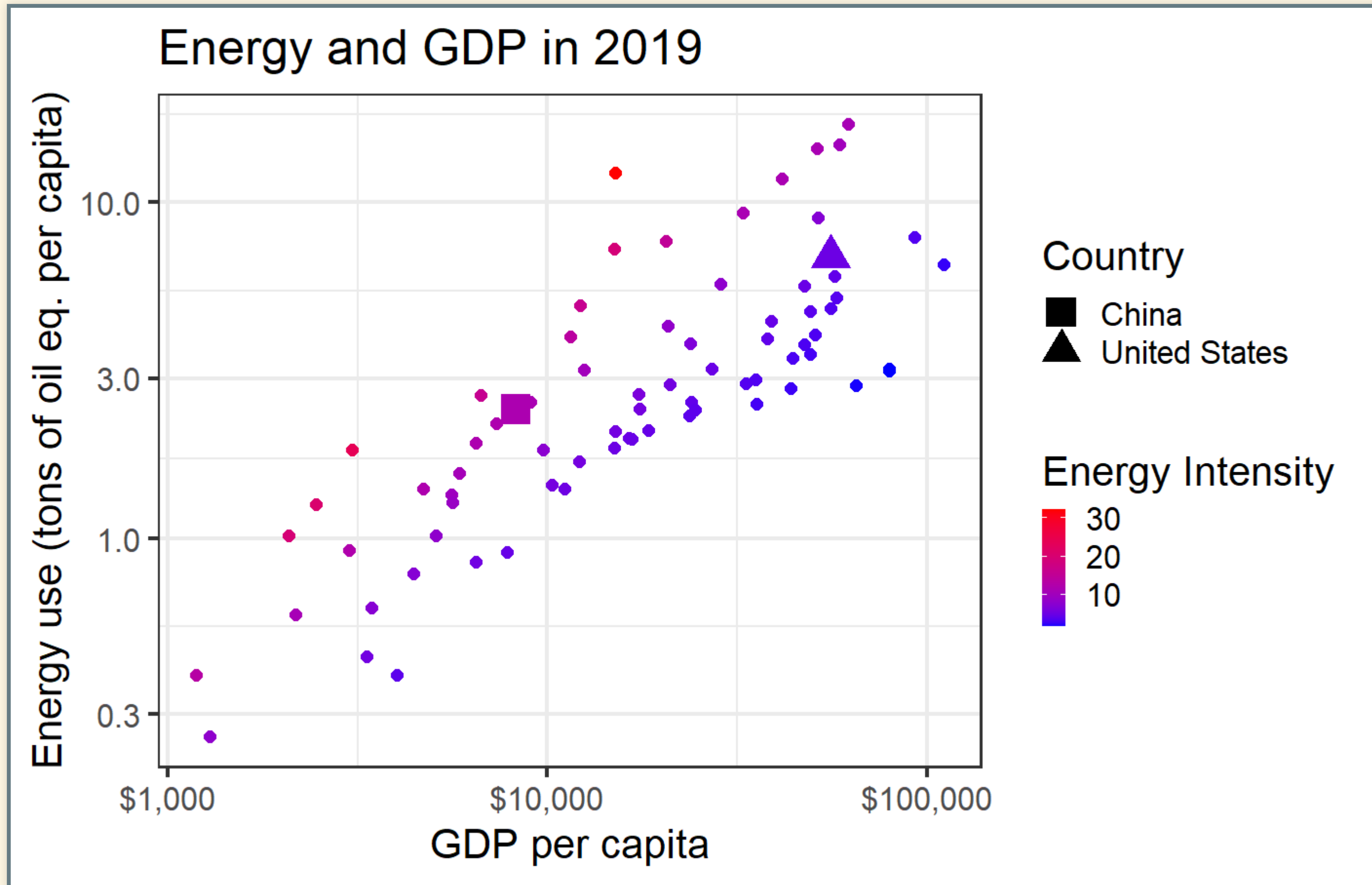
P = population

$g = G/P$ = per-capita GDP

$e = E/G$ = energy intensity of economy

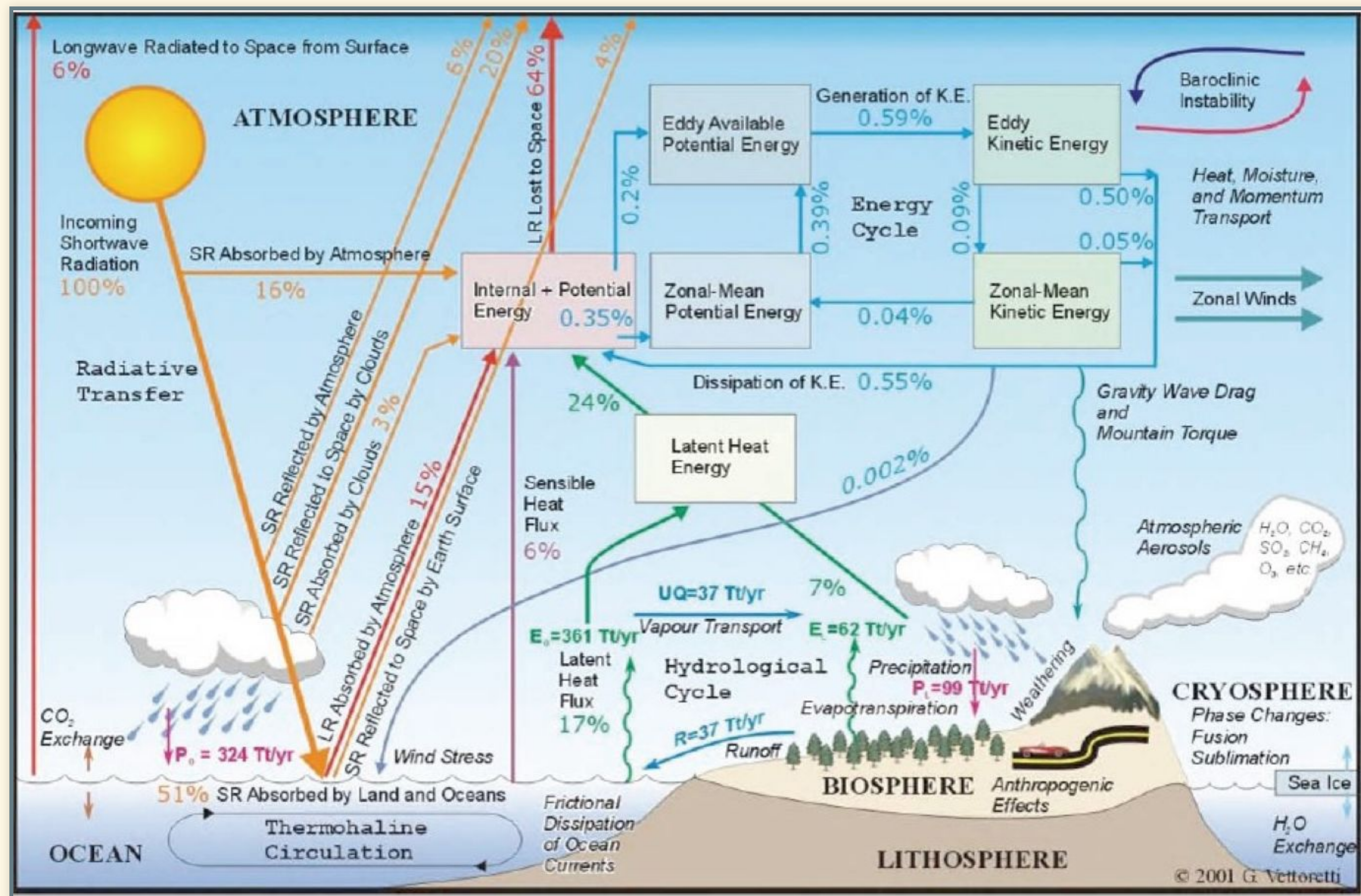
$f = F/E$ = CO₂ intensity of energy supply

Kaya Identity in Practice

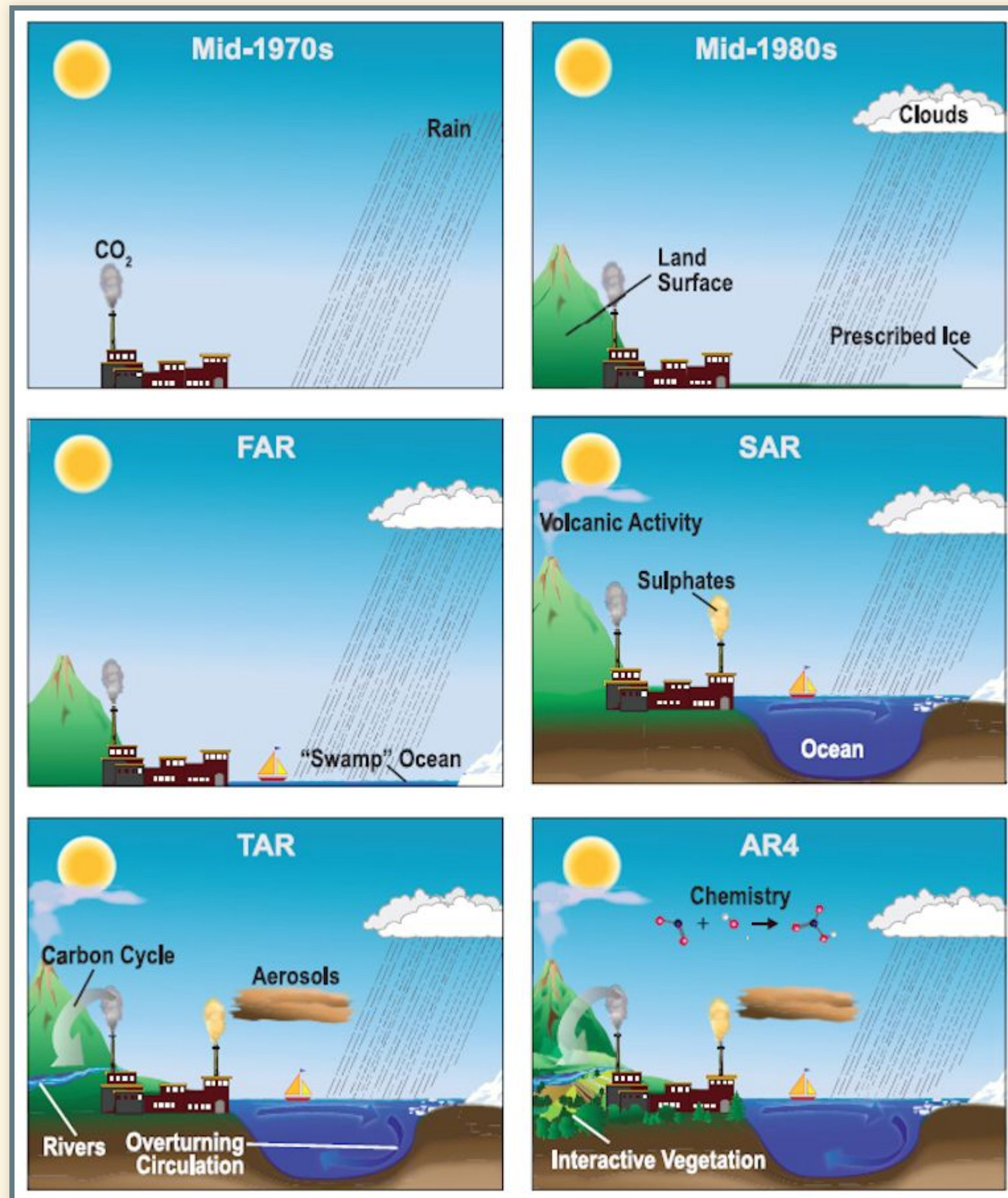


Computer Models of Climate

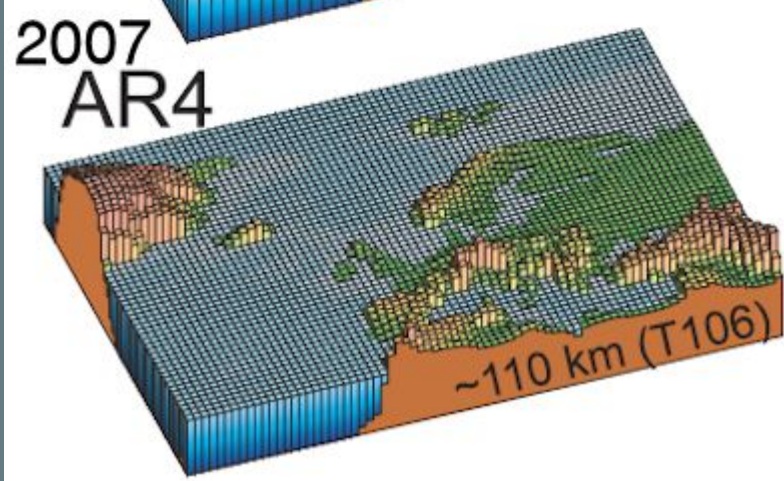
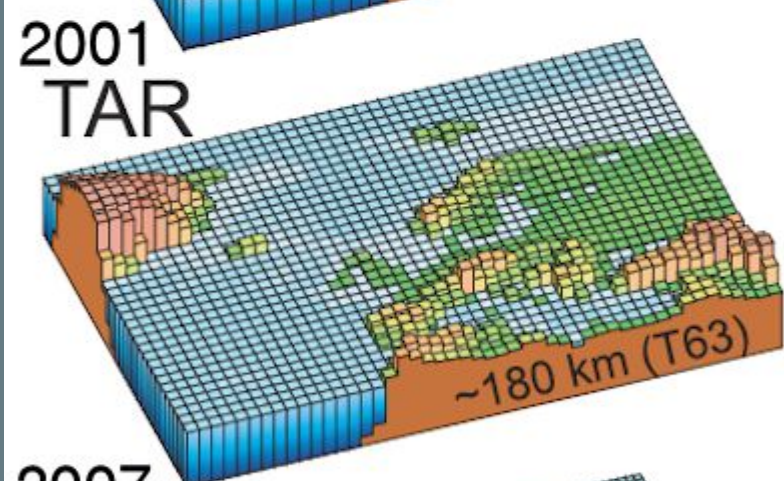
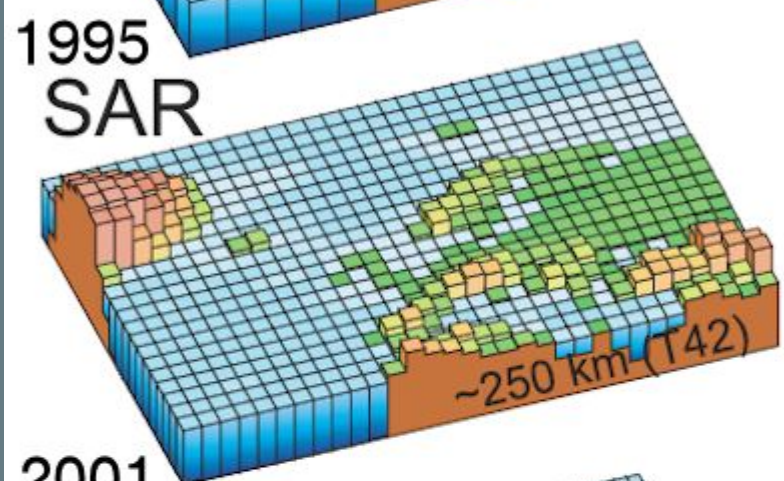
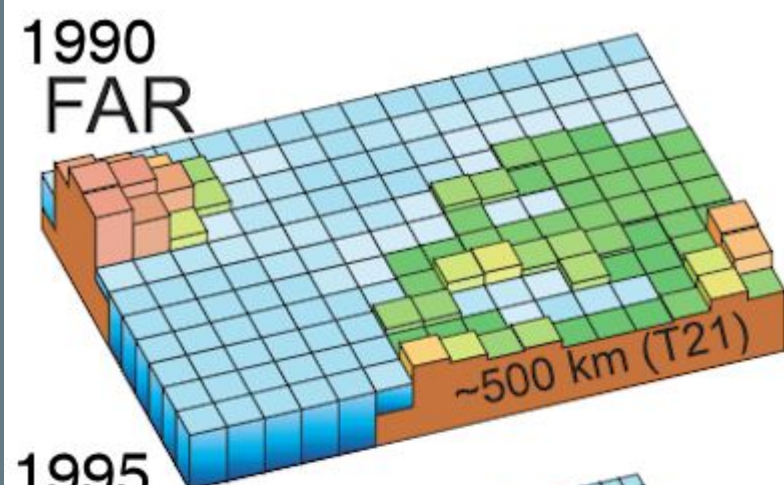
Computer Models of Climate



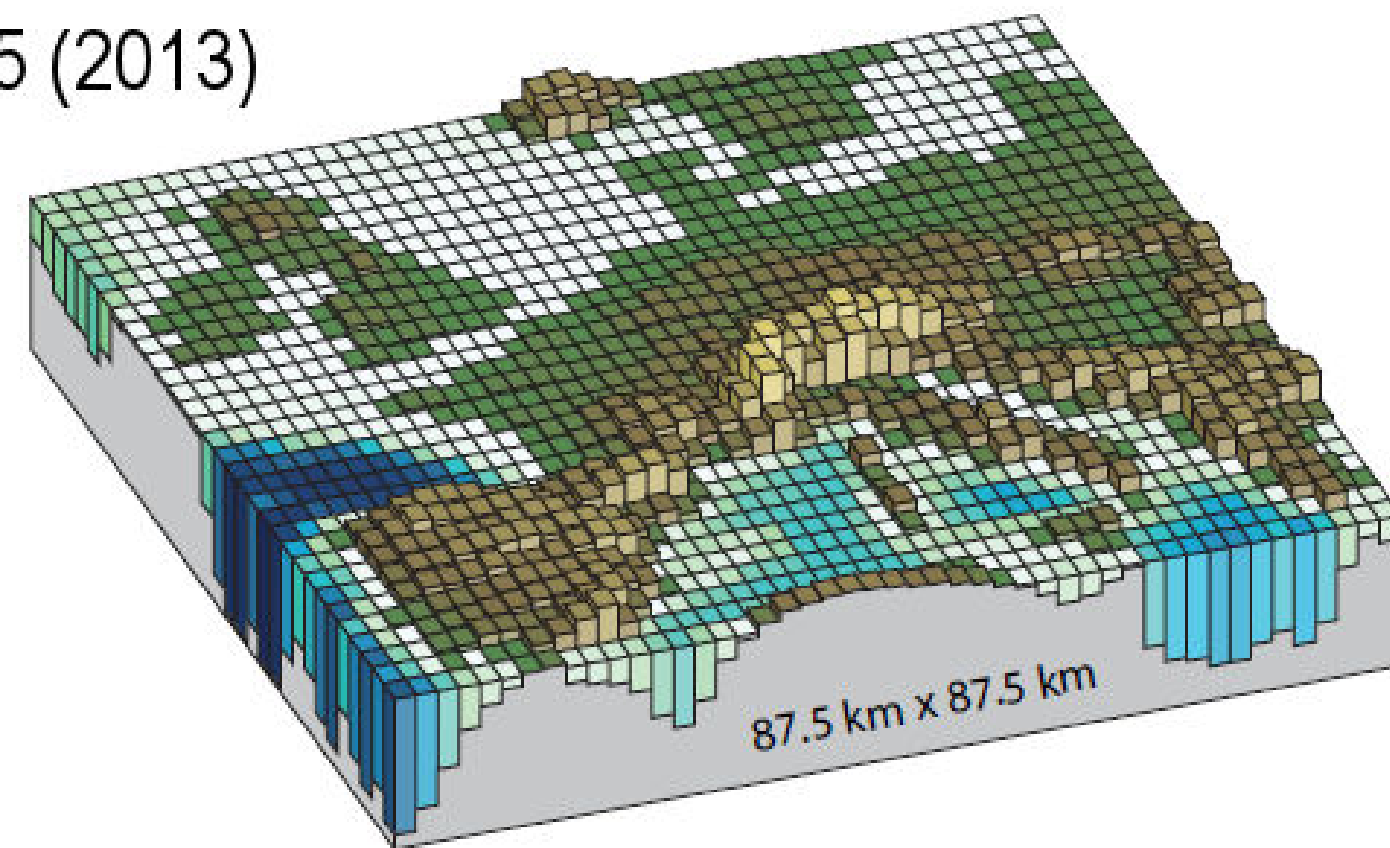
Computer Models



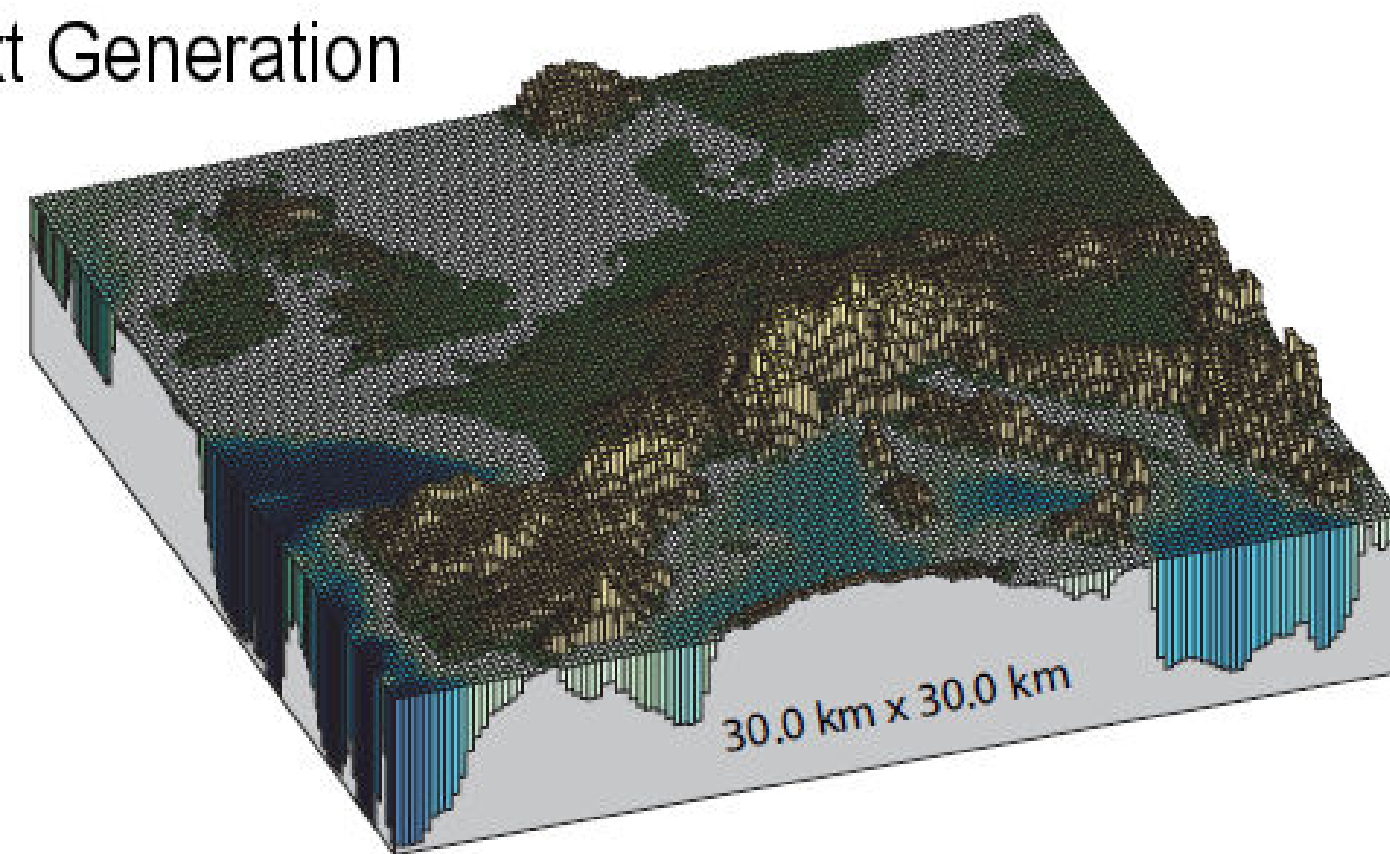
Computer Models



AR5 (2013)

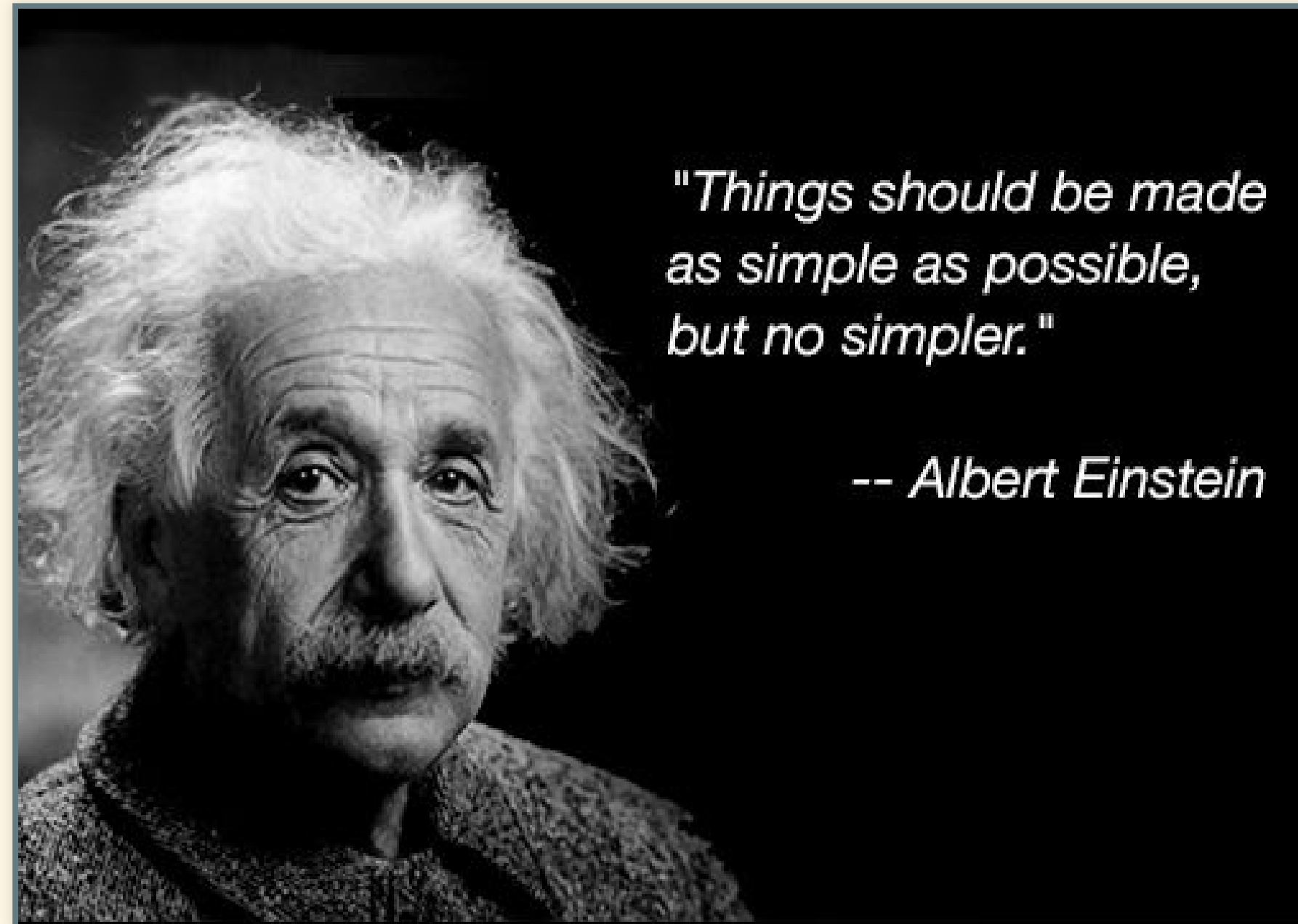


Next Generation



Principles of Computer Modeling

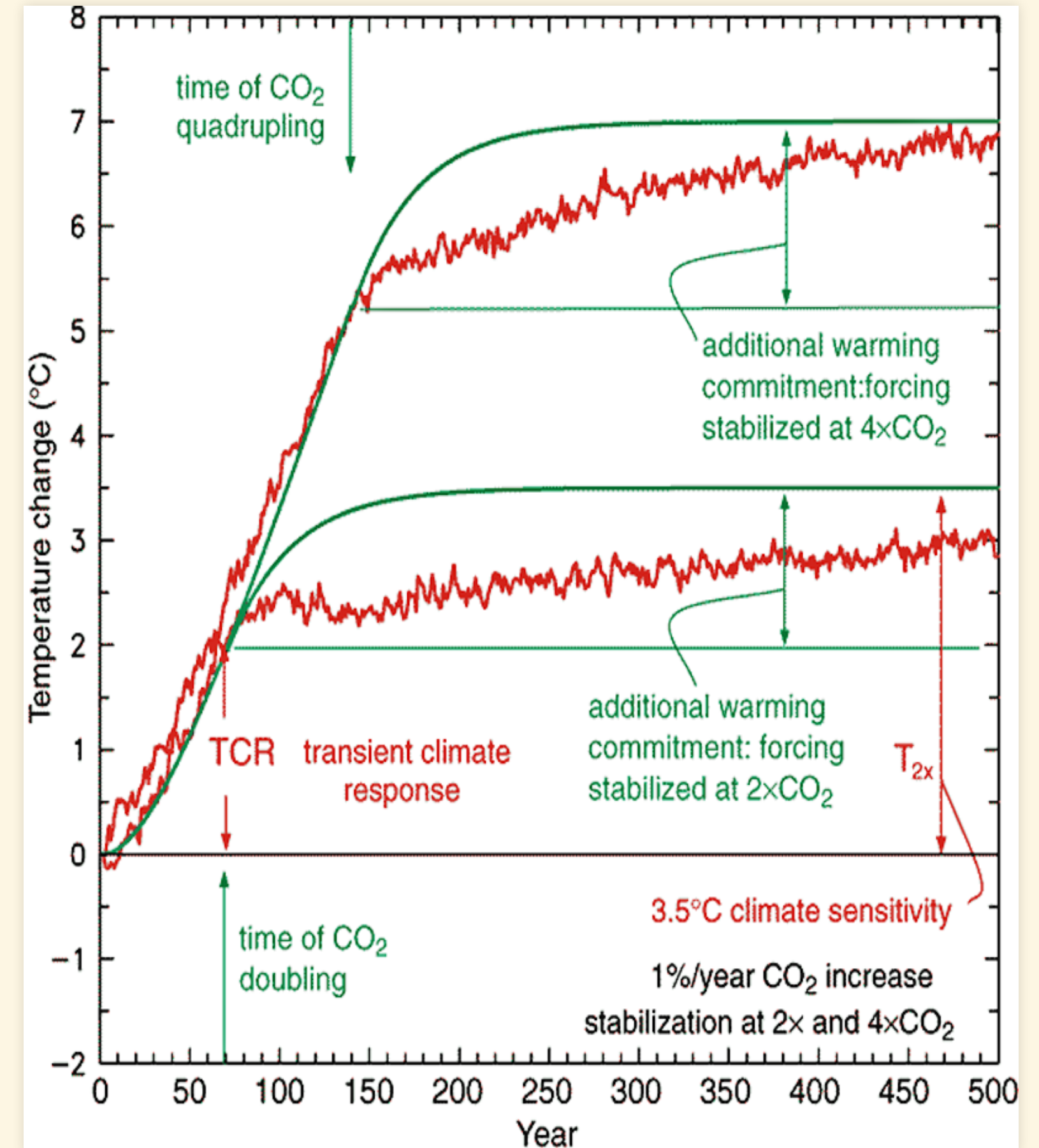
- Make models as simple as possible:
 - Start simple
 - Add complexity only as needed
 - Different models for different purposes
 - Check model against real world



Transient vs. Equilibrium Response

Transient vs. Equilibrium Response

- Gradually raise CO_2 and then stop.
- Planet takes time to heat up
 - Oceans absorb heat
 - Like pot of water on stove
- Transient response:
 ΔT when CO_2 stops changing
- Equilibrium response:
Stable temperature (much later)
 - Green: Atmosphere & surface ocean
 - Red: Atmosphere, surface ocean, & deep ocean.
- Equilibrium takes many decades.



Modeling for Science vs. Policy

Modeling for Science vs. Policy

Integrated Assessment Models (IAMs)

- Combine climate system and world economy
 - Emissions as a consequence of economic activity
 - Energy use for production (factories, etc.)
 - Energy use for consumption (households, etc.)
 - Farming: fertilizers, livestock, paddy fields, etc.
 - Climatic impacts on economy
 - Cost of severe weather
 - Sea level rise
 - Droughts & heat waves
 - ...
- **Optimize for greatest net economic output**

Climate Projections

- Biggest uncertainty in predicting future climates is GHG emissions
 - We can predict consequences of emissions
 - We can't predict what emissions will be
- Scenarios and Pathways:
 - **Scenario**: possible future,
 - Story of economic & political development → resulting emissions
 - **Pathway**: possible future,
 - Trajectory of emissions → economic activity that might cause them
- Projections:
 - Conditional predictions:
 - “**If** emissions do this, **then** climate will do that.”

Projections for future emissions in US:

	2010	2050	Growth rate
g (\$/person)	42,300	83,495	1.7%
ef (tons/\$million)	432	228	-1.6%
P (millions)	309	393	0.6%
Total Emissions F (million tons CO ₂)	5,647	7,471	$1.7 - 1.6 + 0.6 = \mathbf{0.7\%}$

Projections for future world emissions:

	2010	2050	Growth rate
g (\$/person)	9,780	22,654	2.1%
ef (tons/\$million)	522	275	-1.6%
P (millions)	6,410	9,188	0.9%
Total Emissions F (million tons CO ₂)	32,724	57,289	$2.1 - 1.6 + 0.9 = \mathbf{1.4\%}$

Uncertainties in Projections

Projections for future world emissions:

	2010	2050	2100	Growth rate
g (\$/person)	9,780	22,654	64,737	2.1%
ef (tons/\$million)	522	275	124	-1.6%
P (millions)	6,410	9,188	14,409	0.9%
Total Emissions F (million tons CO ₂)	32,724	57,289	115,366	1.4%

Uncertainties in Projections

Projections for future world emissions
with slightly different growth rates:

	2010	2050	2100	Growth rate	Δ rate
g (\$/person)	9,780	24,541	77,505	2.3%	0.2%
ef (tons/\$million)	522	298	148	-1.4%	0.2%
P (millions)	6,410	9,563	15,766	1.0%	0.1%
Total Emissions F (million tons CO ₂)	32,724	69,973	180,930	1.9%	0.5%
Difference		12,684	65,564	0.5%	
Difference (%)		22%	57%		